Farmer's Handbook on Concrete Construction

"Concrete for Permanence"

Published by

Portland Cement Association

111 West Washington Street

Chicago, Ill.

May, 1916

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THE fact that concrete is a plastic material and is easily cast in any required shape makes it especially adapted to farm structures. If properly made it will last forever. Its durable qualities are such that it means the elimination of cost for repairs and renewals. It is a dense and impervious substance affording no harbor for rats, vermin, and other destructive agencies. With the exception of the Portland cement, the necessary materials are usually found upon the farm. For the reasons stated, concrete makes strong appeal to the farmer.

The actual money saved in repairs and reconstruction will soon offset any excess cost over other materials. It is often the case, however, that concrete structures cost no more than buildings of other materials, and often less.

The farmer can ordinarily do the work with the assistance of his farm hands, making it unnecessary to hire an expert carpenter or mason. Great economy is achieved in this way.

Perhaps the greatest benefit to be derived from concrete construction is the elimination of fire risk. This is of vital importance to the farmer, who is usually too far from a town to permit of any real protection from fire.

Aggregates to be Used in Concrete Construction

The sand, stone, and gravel usually found upon the farms of the United States are generally suitable for concrete construction, provided the following precautions are taken:

1. These aggregates must be free from vegetable matter, clay, loam, or other foreign substances.
2. Never use bank-run gravel, unless the sand is separated from the pebbles by screening through a ¼-inch screen.
3. For small concrete products, such as drain tile, fence-posts, etc., the coarse aggregate (crushed rock or pebbles) should range in size from ½ inch to ¼ inch. For larger work, such as silos, barn floors, ordinary foundations, etc., coarse aggregate should range from 1½ inches to ¼ inch.
4. The sand used should be coarse, hard, and clean, and graded from ¼ inch to fine, with the larger size predominating.

machine mixer if the farmer intends to use concrete in large quantities.

Hand Mixing

Use great care in hand mixing. It is economical to buy a small machine mixer if the farmer intends to use concrete in large quantities.

Hand Mixing

The process to be followed when concrete is mixed by hand, using a two-bag batch of 1 : 2 : 4 proportions:

1. Size of measuring box for sand should be 2 feet square by 1 foot high, thus containing 4 cubic feet.
2. Load sand in wheelbarrows and wheel onto board.
3. Fill measuring box with sand, lift box, and spread sand 4 inches thick over board.
4. Take two bags of cement, place contents as evenly as possible over sand.
5. Turn the sand and cement over until thoroughly mixed, so that no streaks of cement or sand appear.
6. Spread the mixture of sand and cement out carefully, place measuring box beside it, and fill twice with stone or pebbles, then empty onto sand and cement mixture and mix thoroughly.
7. Add three-quarters of required amount of water slowly and evenly, at same time mixing the mass.
8. Continue mixing, adding balance of water when dry spots appear, until whole mass has been turned over three or four times; this should be sufficient. After final turning, shovel into compact mass ready for wheeling away to place.

Below will be found a list of firms which manufacture small concrete mixers suitable for the home concrete worker's requirements. Any of these concerns will be glad to send their literature and full details of their equipment upon request.

Albany Hardware Specialty Co., Albany, Wis.
American Cement Machinery Co., Keokuk, Iowa.
Archer Iron Works, 2436 West 34th Place, Chicago.
Associated Manufacturing Co., Waterloo, Iowa.
Atlas Engineering Co., 784 30th St., Milwaukee, Wis.
Badger Concrete Mixer & Machinery Co., Majestic Building, Milwaukee, Wis.
Blystone Batch Mixer Co., Cambridge Springs, Pa.
Cement Tile Machinery Co., 110 Roth St., Waterloo, Iowa.
Chain Belt Co., Milwaukee, Wis.
Chicago Builders Specialties Co., Old Colony Bldg., Chicago.

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Chicago Builders Specialties Co., Old Colony Bldg., Chicago.

W. E. Dunn Manufacturing Co., Holland, Mich.
Excelsior Mixer & Machinery Co., Milwaukee, Wis.
Ideal Concrete Machinery Co., Cincinnati, Ohio.
Iowa Foundry & Manufacturing Co., Ft. Dodge, Iowa.
Jaeger Machine Co., 214 North Rich St., Columbus, Ohio.
Koehring Machine Co., Milwaukee, Wis.
Lansing Company, Lansing, Mich.
Milwaukee Concrete Mixer & Machinery Co., 135 West Washington St., Chicago.
Municipal Eng. & Contracting Co., 607 Railway Exchange Bldg., Chicago.
National Mixer Co., 100 Fifth St., Oshkosh, Wis.
Northfield Iron Co., Northfield, Minn.
Northwestern Steel & Iron Works, Eau Claire, Wis.
Raber & Lang Manufacturing Co., Kendallville, Ind.
Ransome Concrete Machinery Co., 1336 Monadnock Block, Chicago.
Republic Iron Works, Tecumseh, Mich.
George T. Sheldon, Nehawka, Neb.
Sioux City Engineering & Machinery Co., Sioux City, Iowa.
T. L. Smith Co., Milwaukee, Wis.
Standard Scale & Supply Co., 1345 Wabash Ave., Chicago.
Sterling Machinery Co., La Crosse, Wis.
Chas. H. Stehling Co., 401 4th St., Milwaukee, Wis.
Turner Manufacturing Co., Port Washington, Wis.
Waterloo Cement Machinery Co., Waterloo, Iowa.

Bank-run Gravel

Bank-run gravel should not be used as it comes from the bank because *no two places* in a bank will have the same proportions of sand and pebbles. It is, therefore, always essential when using bank-run material to screen the sand from the pebbles and remix in the proper proportions.

Portland Cement

The definition of Portland cement adopted by the American Society for Testing Materials is as follows:

> "Portland cement is the term applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly propor-

tioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent. has been made subsequent to calcination."

Portland cement is now manufactured in all sections of the United States. There are few places in which it cannot be conveniently obtained. It is made to pass what are known as "Standard Specifications" devised by the U. S. Government and responsible engineering and technical associations.

QUANTITIES OF MATERIALS REQUIRED FOR VARIOUS MIXTURES OF MORTAR AND CONCRETE

Mixture	Materials for One-Bag Batch			Resulting Volume in Cubic Feet		Quantities of Cement, Sand, and Pebbles or Stone Required for One Cubic Yard of Compacted Mortar or Concrete				
	Cement in Sacks	Sand Cu. Ft.	Pebbles or Stone, Cu. Ft.	Mortar	Concrete	Cement in Sacks	Sand		Stone or Pebbles	
							Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.
1:1½	1	1.5	..	1.75	..	15.5	23.2	.86	..	..
1:2	1	2.0	..	2.1	..	12.8	25.6	.95	..	..
1:2½	1	2.5	..	2.5	..	11.0	27.5	1.02	..	..
1:3	1	3.0	..	2.8	..	9.6	28.8	1.07	..	..
1:2:3	1	2.0	3.0	..	3.9	7.0	14.0	.52	21.0	.78
1:2:4	1	2.0	4.0	..	4.5	6.0	12.0	.44	24.0	.89
1:2½:4	1	2.5	4.0	..	4.8	5.6	14.0	.52	22.4	.83
1:2½:5	1	2.5	5.0	..	5.4	5.0	12.5	.46	25.0	.92
1:3:6	1	3.0	6.0	..	6.4	4.2	12.6	.47	25.2	.94

Concrete Silos

1. There are several types of concrete silos—monolithic, block, cement-stave, and stucco or plastered.

2. Locate silo next to barn with chute facing it. Firm ground is necessary to bear great weight of filled silo.

3. Determine number of animals to be fed and length of feeding, allowing for normal increase in number of animals in future.

This table gives the number of cows in herd and tonnage of silage for both one hundred and eighty and two hundred and forty

days of feeding of 40 pounds of silage per cow, also acreage of corn estimated to fill the silo and the dimensions of the silo itself. The diameters given are such that at least two inches in depth of silage will be taken off daily.

An acre of land gives about one ton of silage for every five bushels of corn. If any acre yields 80 bushels it will produce about 16 tons of silage. This table is based on a yield of 50 bushels, or 10 tons of silage per acre.

Number of Cows in Herd	Feed for 180 Days				Feed for 240 Days			
	Estimated Tonnage of Silage Consumed	Size of Silo		Corn Acreage Required at 10 Tons to Acre	Estimated Tonnage of Silage Consumed	Size of Silo		Corn Acreage Required at 10 Tons to Acre
		Diameter	Height			Diameter	Height	
	Tons	Feet	Feet	Acres	Tons	Feet	Feet	Acres
10	36	10	25	3½	48	10	31	5
12	43	10	28	4½	57	10	35	6
15	54	11	29	5½	72	11	36	7½
20	72	12	32	7	96	12	39	10
25	90	13	33	9	123	14	37	12½
30	108	14	34	11	144	15	37	14½
35	126	15	34	13	168	16	38	17
40	144	16	35	14½	192	17	39	19½
45	162	16	37	16½	216	18	39	22
50	180	17	37	18	240	19	39	24
60	216	18	39	22	288	20	40	29
70	252	19	40	25½	336	20	46	34

Monolithic Silo

1. The University of Wisconsin silo form is recommended if forms are to be made by farmer. (Description in Bulletin No. 21, Association of American Portland Cement Manufacturers.)

2. Both intermittent and continuous doorways may be used.

Reinforcing

Silos must be reinforced both horizontally and vertically. Vertical reinforcement for all diameters ½ inch or ⅝ inch steel rods, spaced 30 inches apart, regardless of the size of the silo. Use twisted square bars if possible. Wire mesh may also be used for reinforcing.

Below is table for amount of horizontal reinforcing:

HORIZONTAL REINFORCING BARS FOR SILOS OF VARIOUS INSIDE DIAMETERS
(USE SQUARE BARS)

DISTANCE IN FEET DOWN FROM TOP OF SILO	8 FT. DIAMETER	10 FT. DIAMETER	12 FT. DIAMETER	14 FT. DIAMETER	16 FT. DIAMETER	18 FT. DIAMETER	20 FT. DIAMETER
	¼ Inch Bars	¼ Inch Bars	⅜ Inch Bars	½ Inch Bars	½ Inch Bars	½ Inch Bars	½ Inch Bars
	Inch	Inch	Inch	Inch	Inch	Inch	Inch
Top to 5 ft.	24	24	24	24	24	24	24
5 ft. to 10 ft.	15½	12	24	24	24	24	24
10 " " 15 "	10½	8½	16	24	20	19	17
15 " " 20 "	7½	6½	12	18	16	14	12
20 " " 25 "	6	5	9½	14	12½	11	10
25 " " 30 "	5	4	8	12	10½	9½	8½
30 " " 35 "	..	3½	7	10½	9	8	7½
35 " " 40 "	..	3	6	9	8	7	6½
40 " " 45 "	..	..	5	8	7	6	5½
45 " " 50 "	..	..	4½	7	6½	5½	5

MIXING

For foundation and floor use—1 : 2½ : 5 mixture of crushed stone or pebbles; for walls use 1 : 2½ : 4.

All materials are proportioned by volume; 1 bag cement equals 1 cubic foot.

Silo Walls

All walls are made 6 inches thick, with reinforcement placed in center. There are seven operations in building silo walls, which are as follows:

1. The reinforcement must be placed ready for the concrete.
2. The forms set in position.
3. The concrete mixed and placed in the forms around the reinforcement.
4. The outside form loosened and raised and reset.
5. The reinforcement placed for the next course.
6. The inside form loosened, hoisted, and reset, ready for the next section of concrete.
7. Openings formed in walls for doors, provision made for roof and chute, and other details.

If rough spots are left when forms are removed from interior of walls, these can be smoothed over by applying a coat of mortar of

1 part cement and 1 part fine sand, mixed with water to consistency of cream. Before applying, brush wall with dry, stiff brush. Wet wall and apply wash.

Concrete Roof

The concrete for the roof is laid 4 inches thick on a temporary wooden roof, which will be removed in two or three weeks, when the concrete attains its strength and becomes self-supporting. The concrete should be reinforced with steel rods $\frac{3}{8}$ inch in diameter. Some of the rods are laid like the spokes of a wheel, 1 inch from the under side of the roof. At the eaves the rods are 18 inches apart; but every other rod runs only half-way to the peak, where it is tied to a horizontal ring extending entirely around the roof. There are four of these horizontal rings equally spaced from the eaves to the center of the roof. Where the straight or radial rods meet at the peak they should be hooked and securely tied together. In the eaves an additional ring is placed, around which are hooked the outer ends of the straight rods. Lower the inner form 6 inches to allow for forms of the roof.

List of Manufacturers

Monolithic Silo Forms:

W. H. Limberg, Plymouth, Wis.
McCoy Silo Form Co., Inc., Berger Building, Pittsburgh, Pa.
Monolithic Silo and Construction Co., Chicago, Ill.
New Enterprise Concrete Machinery Co., Chicago, Ill.
Polk-Genung-Polk Co., Fort Branch, Ind.
Reichert Manufacturing Co., Milwaukee, Wis.
Conklin Construction Co., Hartford, Mich.
St. Jacobs Lumber and Hardware Co., St. Jacobs, Ill.
Silo Equipment Co., Minneapolis, Minn.
Chicago Builders Specialties Co., Chicago, Ill.
Concrete Silo Form Co., Dallas, Texas
Van Guilder Hollow Wall Co., Rochester, N. Y. (hand machine).

Cement Stave Molds:

Cement Stave Silo Co., Des Moines, Ia.
Diamond Concrete Stave Silo Co., Kansas City, Mo.
Interlocking Cement Stave Silo Co., Des Moines, Ia.

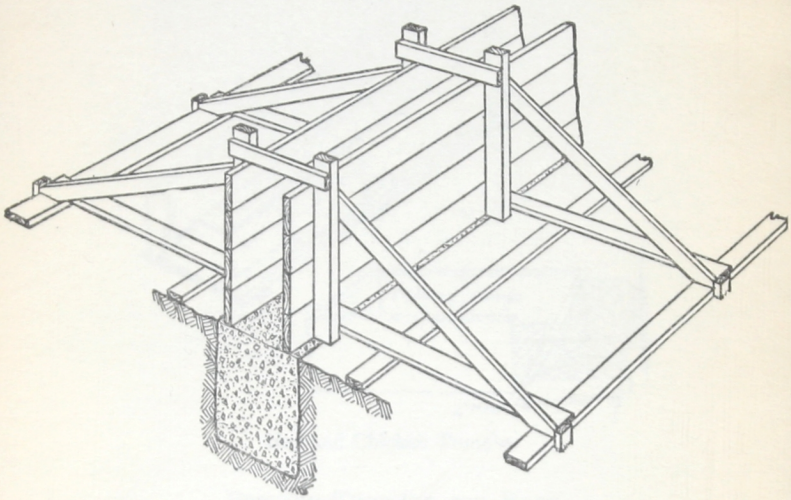
Thickness of Walls for Various Structures

It is impossible to give any hard and fast rule for thickness of walls.

The following, however, may prove of assistance:

1. 4-inch walls for light work (troughs, etc.).
2. 6-inch walls for silos, windwalls, etc.
3. 8-inch walls for barns and houses, (one story.)
4. 12-inch walls for light foundations.
5. 15-inch to 24-inch walls for heavy foundations.

When foundations are built in soft ground, widen at base to allow for footing.



Wall Form on Top of Ground

For small buildings, such as milk-houses, hydraulic ram houses, spring-houses, and poultry sheds, where no cellar is necessary, this form is used. By increasing the height of the form, it can be employed for building windwalls to protect cattle from cold winds in winter

Simple Wall Construction

Walls for small buildings, etc., should be made 6 inches thick and the concrete mixed 1 : 2 : 4. The forms should consist of 1-inch siding nailed to 2 x 4 inch studding. Space studs 2 feet apart and the 1-inch sheathing is nailed to the sides of the studding toward the concrete. The bottoms of the studs rest on the con-

roots foundation and are held in position by strips nailed to them

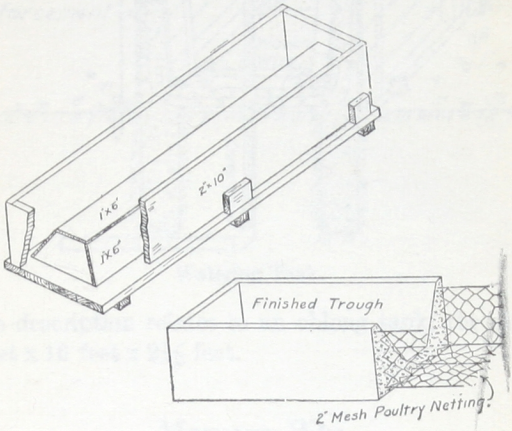
crete foundation and are held in position by strips nailed to them and extending to stakes driven firmly into the ground.

Feeding Troughs

These troughs can be made any size—from small troughs for chickens to large cattle troughs.

Mix concrete 1 : 2 : 3, making the concrete a mushy wet consistence, and spade thoroughly in forms.

Ordinary sized troughs can be built for from 75 cents to $1.00. Use wire mesh for reinforcing.



Hog and Chicken Troughs.

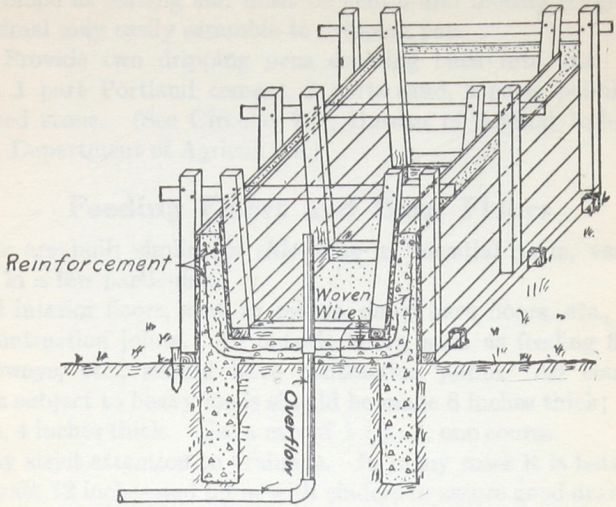
Feeding Troughs for Hogs

Feeding troughs for hogs are usually built as a part of the feeding floor.

Watering Tanks

Watering tanks vary in both size and shape. The size is governed by the capacity required and the shape is a matter of preference. The depth should be about 2½ feet, the walls 5 inches or 6 inches at top and 8 inches or 10 inches at bottom. The sloping face allows ice to slip up sides and not push against them. The inflow and outflow pipes should be 1½ inches in diameter. Lay ½ inch

steel rods entirely around the tank 2 inches from the top and 1 inch from both inner and outer edges. Lay wire mesh in bottom and sides of troughs as shown in drawing below.



Watering Tank.

The above description relates to an oblong tank, the dimensions being 5 feet x 16 feet x 2½ feet.

Manure Pits

Concrete manure pits will save from 30 per cent. to 50 per cent. of the manure's strength by preventing it from leaching out, due to heavy rains, and from firing or heating caused by lack of sufficient moisture.

Mix the concrete 1 : 2½ : 4. The size of a manure pit will have to be determined in each case. The walls are 6 inches to 8 inches thick and floor 5 inches thick.

Dipping Vats

Four important points to be considered in building dipping vats:

1. An entering slide, steep enough to shoot the animal in, but not a direct drop.

2. Must be narrow enough not to allow turning around; long enough so as to keep the animal in for one or two minutes, and deep enough to cover him when taking the plunge.

3. Slope at leaving end must be gentle and footing roughened so animal may easily scramble to dripping pen.

4. Provide two dripping pens draining back into vat. Mix walls 1 part Portland cement, 2 parts sand, 4 parts pebbles or crushed stone. (See Circular 207, Bureau of Animal Industry, U. S. Department of Agriculture.)

Feeding Floors and Barn Floors

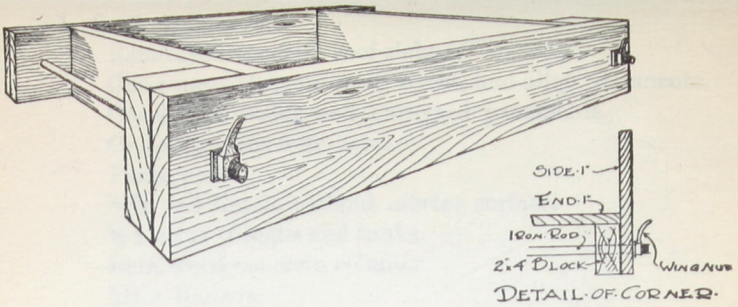
These are built similar to sidewalks in essential parts, varying only in a few particulars.

All interior floors, such as cellars, dairy barn floors, etc., need no contraction joints. All outside floors, such as feeding floors, driveways, etc., should have contraction joints. All concrete floors subject to heavy loads should be made 6 inches thick; light loads, 4 inches thick. Use a mix of 1 : 2 : 3, one course.

Pay strict attention to drainage. In many cases it is better to excavate 12 inches and fill in with cinders to assure good drainage, at the same time providing a drain from the cinders to some free outlet.

Drain Tile Machinery and Molds

Sanford Concrete Machinery Co., Toledo, O.
Acme Tile Machine Co., La Grange, Ind.
Leavitt Mfg. Co., Urbana, Ill.
Monarch Mfg. Corporation, Boone, Ia.
J. B. Foote Foundry Co., Frederickstown, O.
Francis Machinery Co., 109 Market St., St. Louis, Mo.
Iowa Foundry & Mfg. Co., Ft. Dodge, Ia.
Groh Bros., Kendallville, Ind.
W. E. Dunn & Co., 4138 Fillmore St., Chicago, Ill.
Besser Mfg. Co., Alpena, Mich.
Cement Tile Machinery Co., Waterloo, Ia.
Sioux City Engine & Machinery Co., Sioux City, Ia.
Ideal Concrete Machine Co., Cincinnati, O.
Raber & Lang Mfg. Co., Kendallville, Ind.
Lansing Co., Lansing, Mich.
Nappanee Iron Works, Nappanee, Ind.



Form for Casting Concrete Slabs for Simple Sidewalks.

For floors of milk-houses and spring-houses, or other small buildings with floors resting on the ground, and for walks; small slabs of concrete are very convenient. The slabs are cast at any convenient time and stored until needed. For walks where no great weight will come upon them, the slabs can be made 2 inches thick and about 2 by 3 feet in size. For floors the slabs should be made thicker.

Average Proportions

As many users of concrete do not wish to take the trouble to test their own materials, it is customary for them to use the proportions which have been found to produce satisfactory results under average conditions. These are 1 part of cement, 2 parts of sand, and 4 parts of coarse aggregate (expressed 1 : 2 : 4) for most classes of construction. In the manufacture of products large enough to use aggregate exceeding one inch in greatest dimension the proportion of coarse aggregate may be increased accordingly. Conversely, where a fine texture is desired for ornamental purposes, the proportion of cement must be increased, reaching its maximum in 1 : 1½ mortar for troweled surfaces. The following table gives the proportions recommended for various classes of work:

1 : 1: 1 mixture for:

The wearing course of two-course floors subject to heavy trucking, such as occurs in factories, warehouses, on loading platforms, etc.

1 : 1 : 1½ mixture for:

The wearing course of two-course pavements, in which case the pebbles or crushed stone is graded from ¼ to ½ inch.

1 : 2 : 3 mixture for:

Reinforced concrete roof slabs.
One-course concrete road, street, and alley pavements.
One-course walks and barnyard pavements.
One-course concrete floors.
Fence posts.
Sills and lintels without mortar surface.
Watering troughs and tanks.
Reinforced concrete columns.
Mine timbers.
Construction subjected to water pressure, such as reservoirs, swimming pools, storage tanks, cisterns, elevator pits, vats, etc.

1 : 2 : 4 mixture for:

Reinforced concrete walls, floors, beams, columns and other concrete members designed in combination with steel reinforcing.
Concrete for the arch ring of arch bridges and culverts; foundations for large engines causing heavy loading, some impact and vibration.
Concrete work in general subject to vibration.
Silo walls, grain bins, coal bins, elevators and similar structures.
Reinforced concrete sewer pipe.

1 : 2½ : 4 mixture for:

Building walls above foundation, when stucco finish will not be applied.
Walls of pits or basements, subject to considerable exposure to moisture but practically no direct water pressure.
Manure pits, dipping vats, hog wallows.
Backing of concrete block.
Base of two-course pavements.

1 : 2½ : 5 mixture for:

Walls above ground which are to have stucco finish.
Base of two-course sidewalks, feeding floors, barnyard pavements and two-course plain concrete floors.
Abutments and wing walls of bridges and culverts, dams, small retaining walls.

Basement walls and foundations for ordinary conditions, where watertightness is not essential.

Foundations for small engines.

1 : 3 : 6 mixture for:

Mass concrete such as large gravity retaining walls, heavy foundations and footings.

1 : 1½ mixture for:

Inside plastering of water tanks, silos, and bin walls, where required, and for facing walls below ground when necessary to afford additional protection against the entrance of moisture.

Back plastering of gravity retaining walls.

1 : 2 mixture for:

Scratch coat of exterior plaster (cement and stucco).

Facing blocks and similar cement products.

Wearing course of two-course walks, floors subjected to only light loads, barnyard pavements, etc.

1 : 2½ mixture for:

Intermediate and finish stucco coats.

Fence posts when coarse aggregate is not used.

1 : 3 mixture for:

Concrete block when coarse aggregate is not used.

Concrete brick.

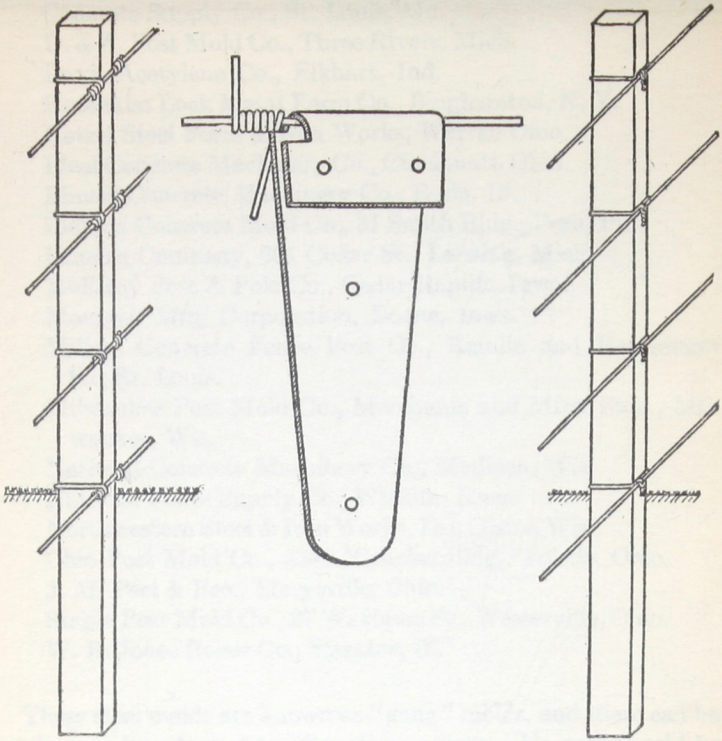
Concrete drain tile and pipe when coarse aggregate is not used.

Ornamental products.

It is not necessary to use waterproofing compounds if care is taken to make a dense concrete. Pay particular attention to proportions, material, and proper mixing and placing, in order to get dense and impervious concrete. The concrete should be mixed to a mushy consistence and should be well spaded after placing in the forms. Careful work at the start will save much unnecessary expense later on.

Fence-posts

The usual size is 7 feet long, 3 inches square at top, and 5 inches at bottom, or 4 inches square at top and 4 inches by 6 inches at



Methods of attaching fence wire to concrete posts.

bottom. Do not make holes through post to attach wire, if possible to avoid, as it tends to weaken the post.

If the farmer contemplates constructing a large number of posts, it would be economical to buy steel molds manufactured by one of the several companies in this line—see list given below:

MANUFACTURERS OF POST MOLDS

H. F. Abbott, 201 E. Main St., Jackson, Mich.
American Cement Machine Co., Keokuk, Iowa.
W. W. Bailey, Chadwick, Ill.
Cement Machine Co., Guthrie Center, Iowa.
Cement Tile Machinery Co., Waterloo, Iowa.
Cement Machinery Co., Jackson, Mich.

Concrete Supply Co., St. Louis, Mo.
D. & A. Post Mold Co., Three Rivers, Mich.
Davis Acetylene Co., Elkhart, Ind.
Hotchkiss Lock Metal Form Co., Binghamton, N. Y.
Hetzel Steel Form & Iron Works, Warren Ohio.
Ideal Concrete Machinery Co., Cincinnati, Ohio.
Illinois Concrete Machinery Co., Buda, Ill.
Indiana Concrete Mold Co., 31 Smith Bldg., Peru, Ind.
Lansing Company, 601 Cedar St., Lansing, Mich.
McElroy Post & Pole Co., Cedar Rapids, Iowa.
Monarch Mfg. Corporation, Boone, Iowa.
Millam Concrete Fence Post Co., Keinlin and Hamburger St., St. Louis.
Milwaukee Post Mold Co., Merchants and Mfrs. Bldg., Milwaukee, Wis.
National Concrete Machinery Co., Madison, Wis.
National Fence Supply Co., Wichita, Kans.
Northwestern Steel & Iron Works, Eau Claire, Wis.
Ohio Post Mold Co., 1341 Nicholas Bldg., Toledo, Ohio.
J. M. Peel & Bro., Marysville, Ohio.
Staple Post Mold Co., 27 W. Home St., Westerville, Ohio.
W. B. Jones Boiler Co., Streator, Ill.

These steel molds are known as "gang" molds, and there can be made anywhere from 4 to 12 posts at a time. No post should be used until at least one month old. For this reason keep a supply of posts on hand. It is a good idea to make up a supply indoors during the winter, in order to be ready for spring.

Embed in each corner of post, ¾ inch from the surface, a ¼-inch steel rod.

Portland Cement-Concrete Roads

Portland cement has proved to be the ideal material for highways. Construction increased from about a half million square yards in 1909 to approximately 17,000,000 square yards in 1916. Conspicuous advantages of the concrete road are extreme durability, reasonable first cost and almost negligible maintenance outlay. They are especially adapted to rural roads as they have an even but gritty surface, preventing horses from slipping. They

cannot be transformed into mud or dust and are passable at all seasons.

FIRST COST OF VARIOUS TYPES OF PAVEMENTS

Class of Pavement	Number of Cities	Cost per Square Yard	Cost per Mile 16-ft. Width
Macadam	11	$0.98	$9,212.00
Concrete	144	1.36†	12,766.00
Bituminous macadam	16	1.50	14,100.00
Asphalt	97	1.82†	17,084.00
Brick	277	1.95†	18,305.00
Bitulithic	47	1.98*	18,612.00
Wood blocks	67	2.80†	26,284.00

* From Engineering and Contracting, April 2, 1913.
† From Engineering and Contracting, April 1, 1914.

Combined maintenance and repair costs of types of improved roads other than concrete in Massachusetts, Connecticut, Rhode Island, New Jersey, and New York for eight years—1905 to 1912—average $608 per mile per year.

Additional maintenance costs in individual localities for types of improved roads other than concrete are as follows:

Massachusetts	1912	$676.00 per mile	
New York	1911	926.00 " "	
	1912	1009.00 " "	
New Hampshire	1912	228.50 " "	
Rhode Island	1912	321.00 " "	
New Jersey	1912	907.00 " "	
England	1909–1910	415.00 " "	per year
France	1909	347.00 " "	

Maintenance

Maintenance costs of properly constructed concrete roads should be less than $50 per mile per year.

Construction

An amply drained and thoroughly compacted subgrade is essential.

The sand must be clean and well graded from fine to ¼ inch.

The stone must be clean, hard, and graded in size from ¼ inch to 1½ inch. Crusher-run or bank-run materials must not be used. Accurate measuring devices for measuring materials must be used and the concrete must be mixed in a batch mixer for at least one minute after all materials are in the drum. The proportions to be used for one-course roads are one part of Portland cement, not more than 2 parts of sand, and not more than 3 parts of stone or pebbles.

The concrete is brought to grade with a templet and finished with wooden floats.

The green concrete must be sprinkled as soon as it is firm, covered with earth and kept wet for at least ten days. Traffic is kept off road at least fourteen days.

The following is a list of Association Bulletins:

Bulletin No. 10, "Concrete Surface Finish."
Bulletin No. 18, "Reinforced Concrete Chimneys."
Bulletin No. 21, "Concrete Silos."
Bulletin No. 22, "Portland Cement Stucco."
Bulletin No. 26, "Concrete in the Country."
Bulletin No. 27, "Farmer's Handbook on Concrete Construction."
Bulletin No. 28, "Use of Concrete in Fertilizer Plants."
Bulletin No. 100, "Concrete Highways."
Bulletin No. 104, "Report of Committee on Edison Fire."
Bulletin No. 105, "Factories and Warehouses of Concrete."
Bulletin No. 106, "The Concrete House and Its Construction." ($1.00 postpaid.)
Bulletin No. 107, "Facts Everyone Should Know about Concrete Roads."
Bulletin No. 108, "Concrete Roads in Flooded Districts."
Bulletin No. 109, "Standard Method of Testing and Specifications for Cement."
Bulletin No. 110, "Lessons, General Outline and Suggested Exercises for Manual Training Course in Concrete."
Bulletin No. 111, "Specifications for Concrete Roads, Streets and Alleys with Recommended Practice."
Bulletin No. 115, "Concreting in Winter."
Bulletin No. 116, "Eighth Annual Report of Wayne County."
Bulletin No. 117, "Simple Forms for Concrete."
Bulletin No. 118, "Concrete School Houses."
Bulletin No. 122, "Illustrating the Construction of a Portland Cement Concrete Road.
Bulletin No. 127, "Reprint of Editorial from the Duluth News."
Bulletin No. 128, "Build the Maintenance into the Road."
Bulletin No. 129, "Tennis Courts of Concrete."
Bulletin No. 130, "List of Portland Cement Concrete Highways in the United States and Canada."
Bulletin No. 131, "Equipment for Concrete Road Construction."
Bulletin No. 132, "Remarkable Test of a Concrete Building in the Salem Fire."

Bulletin No. 133, "Concrete Septic Tanks."
Bulletin No. 134, "Concrete Fence Posts."
Bulletin No. 135, "Small Concrete Garages.
Bulletin No. 136, "Concrete Facts About Concrete Roads."
Bulletin No. 137, "Concrete Feeding Floors, Barnyard Pavements and Concrete Walks."
Bulletin No. 138, "Specifications for Concrete Pavements Between Street Car Tracks.
Bulletin No. 139, "Milwaukee County Solves the Highway Problem."
Bulletin No. 140, "Proportioning Concrete Mixtures and Mixing and Placing Concrete."

The United States Government Bulletins are as follows:

Circular No. 207, "Directions for Constructing Vats and Dipping Cattle to Destroy Ticks."
Bulletin No. 481, "Concrete Construction on the Livestock Farm."

If you have any problems in concrete construction, write to the Portland Cement Association, 111 West Washington Street, Chicago, Illinois, for assistance.

Memoranda

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